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Virtual Training Center (R)

Abstract

Air transportation is a growing activity and a very important traffic expansion is expected in the next ten years. This growth, which has been already planned by civil aviation authorities in different countries, implies many efforts and investments to provide sufficient means to ensure a safe and fluent traffic management and reduce delays at airports arrivals.
Navaids and radio communication systems are part of these means. They provide :

- guidance signals to aircrafts enabling them to navigate and land,
- and link between pilots and air traffic controllers for traffic dialog and management tasks.

These elements, navaids and communication aids, are key components for safety in the whole ATM system environment.
The aids availability, MTBF and MTBO, relies not only on technology but also on maintenance operations: preventive, ‘‘routine’’, and corrective, ‘’ fault and drift’’. To ensure a high operational rate, maintenance technicians and engineers have to be fully qualified and well trained during their entire professional career.
This paper describes the ‘’Virtual Training Center’’ tools developed to cope with training problem in navaids maintenance and flight inspection fields. It covers the different issues from initial training up to interactive video distance-training through internet and training traceability during recurrent training sessions. It also includes two practical study cases made during the deployment phase.

Introduction

The following study applies to ground maintenance operator and flight inspection operator in the field of Navaids : ILS, localizer & glide path, VOR standard and Doppler, DME. The results will also be integrated soon for analog and digital radio communication.
As a consequence of our research, most of the technology developed to reach our goals results in a generic tool, which overpasses by far the initial focused field. The reader may extrapolate this approach to his own field of activity and expertise.

Choosing a computer training method.

To select the most appropriate methodology between the general approaches : course base training CBT [1], simulation or a mix of these two, we must evaluate the different issues and constraints related to the field of expertise, the know how we want to transfer or teach to the different family of users.
At a first step, the intended product must be designed to be integrated into an existing training method or this method has to be defined before the development cycle starts.
The basic items of the training method to be defined include at least :

- Goals,
- Constraints,
- Aims,
- Means,
- Course procedure
- Control

During the development of theses items, working group must take care of pedagogical approach. At the end, a cross check must be applied to verify consistent relation between all of them.

Goals

The training system must be able to perform training for :

- Initial technical qualification degree,
- Master technical qualification degree,
- Maintaining skills, which is equivalent to recurrent training.

Basically, an initial trainee needs to acquire general concepts, basic principles and how to use his set of measuring equipments, e.g. receivers, spectrum analyzer and so forth.
An already qualified technician looking for a master degree needs more in depth knowledge :

- on the various types of equipment in order to trouble shoot them,
- on effect of environmental : lateral slope ...
- on effect of multipath on radiated signals.

Recurrent training is mandatory to ensure capability and efficiency of technicians and engineers. As an example, one of the CAP 581 document statement [2], dedicated to flight inspection, is the following ‘’ Organization must have a procedure for ensuring competence of his personnel. This procedure must have provision for regular assessment of competence’’.

These specific recurrent sessions should be accessible to all levels of operator. Outputs of the training session must be monitored to ensure it has been properly performed.

Constraints

The constraints can be summarized in different categories :

- *Operational :* navaids and communication aids must remain available for the final user : airlines. As a consequence, it is really difficult to freeze a runway : ILS, or a facility : VOR, for training purposes. If during one operator's maintenance work cycle, no routine maintenance and/or no failure occurs, this fellow will lose his initial qualification degree.
- *Resource sharing :* instructors, materials, facilities, huge space for field measurements are not available at each airport or at each maintenance workshop. This means cost for transportation and accommodation during training courses. Further-more, even at academies, due to equipment prices, their numbers are limited and all students cannot work at the same time and there are some dead time during courses.
- *Diversity of equipment :* after initial training, including : general concepts and basic principles, a ''type'' qualification must be handled for the different types of equipment installed in the maintenance area.
- *Real feeling and field measurement* Can a fully computerized training course replace a field experimentation for initial trainees? Due to the fact that real life operations require numerous instruments and manipulations, that navaids radiate signals outside of the cabinet and that these signals are affected by external environment, it seems that for initial trainee a balance must be found between a full computerized and similar field/measuring device activity training.
- *Real time operation and dialog :* In a flight inspection environment, real time adjustments and decision processes are everyday operations. Dialog with ground staff as well as pilots, understanding dialog between pilots and air traffic control increases also workload and affects operator capability.

Aims

The simulation tools must be designed :

- To acquire the basic principles : antennas diagrams pattern, vectorial representation, CSB And SBO diagrams, phase/level relation,
- To learn the different links or modules composing a navaid and to apprehend the interaction between them in terms of :
  - radiated signals : transmitters, distribution unit, antenna ...
  - control means : probes, recombine unit, monitors,
- To diagnosis and analyze failures : ''trouble shooting'',
- To commission navaids,
- To perform ground test records, measurement reports and logs,
- To ensure the necessary operations during flight inspections.

Means

These goals are achieved :

- By reproducing the working environment of operators and using :
  - navaids main diagram and schematics,
  - decomposition into modules : transmission, CSB and SBO phase etc.
- By building up the navaids real operating conditions :
  - control panel : Local mode, remote mode,
  - exercises : failure faults,
- By running usual navaids technical means :
  - Measuring devices : ILS receiver, Vectorial receiver, etc.
  - Tools : dummy load, elbows, $\lambda/4$ and $\lambda/2$ cables, etc.

Course method

Maintenance ground staff and flight inspection engineers are trained to maintenance and commissioning procedures by following logical flow diagram :

- Ensuring the different set-up and control operation of navaids modules,
- Controlling the radiated signals with measurements :
  - On static points : Course, Width, Clearance,
  - On dynamic records form maintenance vehicle and flight inspection aircraft,
- Controlling the recombine unit and monitors,

- Switching into remote modes.

Control

The results of the training are controlled as during real operational lifetime of navaids :

- Providing a set of records displaying the correct diagrams for the radiated signals and patterns. This task is equivalent to the logs and reports published by the maintenance team,
- Providing a distance/remote operation mode for the logical control unit. The navaid must remain switched on, ‘’Green’’, without having the control panel circuit switching form TX1 to TX2 nor stopping the navaid in case of a remaining mis-adjustment or failure.

Choosing the technology of a computer aided training system.

Choice between CBT, simulation and mix of the two was relatively easy to do and appeared really natural after the first step ‘’ choosing a training method ’’ was completed. Computer aided training system must replace field and real life maintenance operation :

- Consequence : CBT is not sufficient by itself.

Beginners need to learn and experiment principles/concepts and graduate technicians need to refresh their knowledge :

- Consequence : simulation cannot do that.

Conclusion : Mix simulation/CBT was the right solution.

In detail, due to the complexity of a navaid and the natural feeling a student must get from the software tool, we have chosen to develop a simulator. General concepts, basic principles are supported through an help assistant which is similar to CBT. Student is guided step by step to perform simulation task.

Simulation is not an easy task to achieve and some principles must be defined to provide a pedagogical tool consistent with the training method.

As an example, should we provide a dedicated representation of the navaid looking like a perfect picture of the type installed on the airport? e.g. Thomson 389, Wilcox Mark 10 ... or should we provide a general diagram to develop principles and concepts ?

The answer directly impacts on the software architecture and can be expensive to develop. A market survey made during the general specification phase provides a 50%-50% answer and seems to depend on the habits. After deployment phase, this ratio is still the same and the origin of the opinion seems also confirmed. Detailed information describes this tendency as follows : beginners and teachers need/want a general symbolic approach and graduate technicians prefer to work on the systems installed in their area.

Software kernel

Navaids can be described as a complex loop system, fig 1, composed of basic modules :

- Control panel,
- Electronic unit (1 or 2) : pilot + transmitter,
- Distribution unit,
- Antennas : cables, VSWR, coupling, pattern,
- Recombine unit : probe, cable, recombine device,
- Monitoring channel, up to 6.

Each module interacts with the other ones and can be modeled as follows :

- Outputs (m) = f {Inputs(n) , Adjustment(i), Tools(j, α), Fault(k, β)}

In this equation, tools(j) and faults(k) represent the number of nodes where a given number , α or β, of objects can be inserted by user or teacher.

As an example :

- a transmitter has : 4 outputs, ≅ 25 adjustments, 10(j) tools, 10(k) faults,
- a 25 antennas distribution has : 25*4 outputs, 4 inputs, ≅ 4 adjustments, 29(j) tools, 29(k) faults,

The received signal follows the same rules as the modules. The inputs of the complex matrix are signals at the antenna’s outputs modified by transmission paths and coefficients.

Tools are basic components a student can use like in the everyday maintenance operations : dummy load, Elbows, $\lambda/4$ and $\lambda/2$ cables, etc.

Faults are incorporated by a teacher to create exercises and course. These elements are not visible by the student. He must analyze the situation with his virtual instruments, diagnostic the origin of the faults and compensate them.

To accommodate the loop complexity, the user requirement and the exercises capability, the simulation process is designed around a real time updated database. This solution is efficient and provides a great flexibility and modularity. The real time database kernel allows :

- to extend on request the navaids types. The user can customize by himself the existing ones or create new one,
- to be able to work as a GroupWare : classroom with network capability,
- to download exercises from the Academy through internet,
- to share common resources during a distance-training course.

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It has been stated during the training method definition, that course program must include some practical works, especially for beginners. As for an aircraft pilot, simulation is not enough to become graduated. The technicians need to learn how to use real measuring devices and make physical manipulations on the navaid equipment. In order to perform this complement of training after a first simulation phase and solving the constraints problems mentioned earlier, we develop in close relation with E.N.A.C. [3] (author of the prototype) an hardware simulator VTC300. The type product qualification is delivered on the manufacturer cabinet and the system qualification is delivered on the whole system.
The difference of radiation paths between antennas and the receiver's location are computed and send to electronic attenuators and phasors. At the output of a summator, the radio frequency signal feed a navaids receiver. The receiver is remotely controlled from the computer to perform ground check and flight inspection records.
There is no need for huge free space for radiated signals and no dead time walking outside the classroom's building. The software engine is the same for VTC 300 as for the stand alone simulator VTC100 and the flight inspection one VTC200.

Training traceability and distance-training

To maintain qualification, maintenance operator must practice and perform recurrent training periods. Thanks to the database kernel and the tools/faults capability, the traceability of training can be ensured from the main maintenance workshop. Teacher or examiner do not need to be co-located with maintenance operator. They send exercises/exam through internet and receive them back with the student's solution hopefully.

Distance training is developed using industry technology standards, thanks to Internet. Teacher and student are linked together via the world wide web and interact on their own computers as well as on the computer of the other one. Student computer is shared with the teacher, enabling this one to follow the student's actions. In case, he can control the student simulation session and show the student specific action, performing them from his location. Student terminal is accessible by the teacher : mouse & keyboard actions. Further-more, dialog is full duplex with phone/audio support H.323 standard. If bandwidth is not enough, discussion is able with ''chat'' capability. A multi pages whiteboard T.126 is able for the two in order to replace a classroom blackboard. Video may be added for more friendly session or video conferencing H.263 & H.261 standard. The video capability depends on the bandwidth.

Deployment phase

The VTC200 real-time simulator has been delivered to the Office National Des Aéroports , MOROCCO. During the simulation training period, 6 students have already cumulated a total of 260 hours equivalent flight time. This represents significant savings compared to onboard training.
The new release, 2.0, will implement half duplex phone/audio capability to emulate VHF communication between ground : teacher and aircraft : student. It will replace external phone/audio hardware connections. We will implement also a multi-language text to speech engine to complete the visual interface between virtual pilot and the trainee.
These two new features have been tested and validated in lab but not delivered yet.
20 licenses of the stand alone VTC100 simulator have been delivered at the ''EAMAC'' civil aviation school of Niamey(5) as well as in the main maintenance centers of the 15 countries members of ASECNA based in Africa.
Training traceability is part of the package and upgrade with distance-training will be delivered by the beginning of year 2000.

Summary

The technology developed for the VTC, Virtual Training Center (R), products transpose the traditional methods of simulation in a new world of virtual representation describing perfectly the navaids operational conditions. Their design which includes :

- a global approach of system aspect,
- a global approach of training to reach qualification levels and to maintain skills,

brings forth the master knowledge of techniques and methods necessary to maintenance and flight inspections operators.
This acquired know-how will enable the VTC users to :

- Increase the operational availability of navaids : MTBO, MTBF,
- Reduce the maintenance costs.

Monitoring the training and distance-training through Internet between airports and the main training center allows to :

- Ensure traceability of the technical qualifications,
- Reduce the training costs.

References

[1] A.I.C.C. Aviation Industry CBT Committee
According to A.I.C.C. glossary ***CBT :*** Computer-Based Training. The use of computers to provide an interactive instructional experience. Also referred to as CAI (Computer Assisted Instruction), CAL (Computer-aided Learning), CBE (Computer Based Education), CBI (Computer-based Instruction), etc.
[2] FLI02-CAP581 C.A.A. United Kingdom
[3] Navaids training courses, ENAC-France